AN INSTALLATION FOR MANUFACTURING OF SHAPED ELEMENTS FROM FIBROUS WASTE MATERIAL AND A METHOD OF USING THE SAME

The invention relates to a method and an installation for manufacturing of shaped elements from fibrous waste material, and in particular shaped elements made from rest pulp after remoulding pulp from paper.

Background of the invention

One problem with the reprocessing of recycle paper is the app. 30% rest pulp that cannot be used for paper due to its very short fibre length. The invention is related to a method and an installation for manufacturing shaped elements from a raw material based on said rest pulp being left after remoulding pulp from paper.

From GB 1 405 587 it is known to use this technique where the raw material is laid on a permeable filter belt and pressed through rollers with gradually narrower gaps so as to force water out. The mould may be perforated so as to let water escape while the element is kept under pressure and heat.

WO 94/19539 discloses a moulded element produced on the basis of a raw material. This raw material which mainly consists of water, short fibres, and fine, mineral particles is drained by pressing in a first pressing stage between filter belts for production of a coherent element, dried partially in a first drying stage, pressed in a second pressing stage, and dried finally in a second drying stage. This invention relates to a "batch process" and not a continuous process of producing elements. The invention concerns a similar method for separation of fibres and particles from wastewater which results from repulping paper and reclaiming of fibres from the pulp mass for remanufacturing of paper.

Further apparatuses and methods of producing shaped elements from rest pulp of recycled paper is known from e.g. US 5,134,023, DE 100 41 765, WO 02/08519 and WO 00/09305.

It is an object of the present invention to provide an installation for manufacturing shaped elements having a consistent strength and thickness.

It is an object of the present invention to provide an installation for manufacturing shaped elements continuously and not as a "batch process", and wherein the changeover time (e.g. changing between different lengths of elements) of the production is minimal.

It is a further object to provide an installation for manufacturing of shaped elements, which is flexible for production of various types of elements.

It is a further object to provide a method of manufacturing shaped elements with a minimum wastage percent.

The installation and method according to the invention described below fulfil these objects.

Description of the invention

According to a first aspect, the invention relates to an installation for manufacturing of shaped elements from fibrous waste material, said installation comprising;

- means for mixing a portion of fibrous waste material with at least water,
- at least one conveyor belt for supporting and transporting said mixed mass of waste material and water,
- a first press for pressing and draining the mass for an amount of surplus water,
- a second press adapted to co-operate with said conveyor belt for simultaneously pressing and vibrating the mass, and
- means for cutting said pressed mass into elements of predetermined lengths.

Preferably, the means for mixing comprises an agitator provided in a tank wherein the fibrous material, water (and polymer, cf. below) are conveyed into and mixed together.

The installation may comprise a container positioned just above the conveyor belt, the container being a buffer container ensuring that there always is material entering said conveyor belt.

The conveyor belt may be placed under said container, and the mass may then be laid directly on the belt and conveyed towards said first press, which preferably is a belt press.

The belt press preferably comprises a sort of box having pressing surfaces oppositely arranged in relation to a supporting surface of the conveyor belt supporting the mass, and opposing side surfaces provided in order to avoid mass leaving the conveyor belt from the side during the belt pressing. Thus, the pressing surfaces and the supporting surface together presses the mass.

The belt press comprises a conveyor belt running at the same speed as the conveyor belt supporting the mass. The distance between the pressing surfaces and the supporting

surface of the conveyor belt is decreasing in the conveying direction, so as to press the mass. Said distance may be adjustable by moving the belt press up or down, e.g. by hydraulic cylinders or manually.

Preferably, said pressing surfaces and the supporting surface are perforated to as to drain water from the mass.

Preferably, the second press comprises;

- one or more pressing surfaces oppositely arranged in relation to a supporting surface of the conveyor belt supporting said mass, and
- opposing side surfaces,

at least one said pressing surfaces and/or side surfaces and/or the supporting surface being perforated, so as to drain water from the mass when the mass is pressed between the surfaces, and

wherein at least one of said surfaces is adapted to vibrate in relation to the mass.

It should be understood that the first press might comprise any of the features of the second press mentioned in this application.

The pressing surfaces of the second press may provide a vibration and an eccentric pressing on the mass, but preferably the pressing surfaces provides only a vibrating pressure on the mass. Said second press may be provided with one or more vibrating elements, such as eccentric pressing elements. Preferably, two eccentric pressing elements is provided on each pressing surface of the second press, the two pressing elements running in the same phase rotation so as to provide a "double" pressing effect in contrast to the use of only one pressing element. The pressing surfaces may comprise plates of steel.

Preferably, the second press also comprises a conveyor belt running at the same speed as the conveyor belt supporting the mass for conveying the mass through the press. The conveyor belt of the second press is preferably perforated for draining the mass during pressing.

Preferably, the first and/or second press comprises drainage plates provided on the opposite side of their belts (opposite in relation to side on which the mass is conveyed). Said drainage plates ensure that the drained water running through the belt is guided

away from the belt and to some kind of reception facility. Drainage plates may also be provided below the conveyor belt supporting and transporting the mass.

Preferably, there is a belt for each press, but the first and second press may use the same conveyor belt.

If the mass need to be transported from one belt to another, a supporting plate may be provided between the belts for supporting the mass during the passage. Said plate may be flushed with water, e.g. by nozzles flushing water on the plate, in order to decrease the friction between the plate and the mass.

Preferably, the side portions of the conveyor belt(s) is not perforated, as it is preferred not to drain the mass being closest to the side surfaces of the first and second press in order to minimise the friction between the side surfaces and the mass. A wet mass does not provide as much friction as a hard dried mass. Therefore, a side portion of the belt(s) may be non-perforated by coating it with a lay of e.g. rubber - preferably 2-3 cm of each side of the belt is non-perforated (measured from the side of the belt towards the middle of it).

However, the friction between the side surfaces and the mass may also be avoided by providing the side surfaces of the first and second press with means for moving the mass (such as a conveyor belt).

Preferably, said side surfaces of the first and second press are not perforated, but in an alternative embodiment they could be perforated so as to provide an improved drainage.

The second press may be a combined vibration and eccentric press, or there may be two presses, one providing vibration and the other one providing the eccentric pressure. The transportation of said mass through said second press results in a stable and hard form of the mass.

Preferably, the one or more pressing surfaces of the second press vibrate up and down in relation to the mass and the conveyor belt transporting the mass in such a way that the mass is vibration pressed from above towards the conveyor belt supporting it. However, the pressing surfaces may also vibrate sideways, i.e. perpendicular to the conveying direction of the mass. The vibration frequency is preferably 50-200 Hz, such as 60-190 Hz, such as 70-180 Hz, such as 80-170 Hz, such as 90-160 Hz, such as 100-150 Hz, such as 110-140 Hz, such as 120-130 Hz.

Alternatively, the side surfaces may vibrate in relation to the mass, or the conveyor belt supporting the mass may vibrate in relation to the mass. However, it is an advantage, only vibrating the pressing surfaces of second press and not the conveyor belt supporting the mass, as it is much easier to visually inspect the mass during pressing in order to control the process. Furthermore, it requires considerably less energy to vibrate only the pressing surfaces and not the entire conveyor belt with the mass thereon.

The distance between the pressing surfaces of the second press and the supporting surface of the conveyor belt is preferably decreasing in the conveying direction, and the distance may be adjustable so as to change the amount of pressure on the mass in order to obtain the desired strength of the final shaped element. Said distance may be adjustable by moving the second press up or down.

The second press may comprise one or two or more separate vibrating pressing surfaces, which may be adjacently arranged and at different levels in relation to the conveyor belt supporting the mass, so that the first coming pressing surface, when seen in the conveying direction, is positioned higher than the next and so forth, in relation to said belt.

Before entering the second press, the mass may pass through a parallel nozzle oppositely arranged in relation to said conveyor belt for providing a uniform material thickness and a smoother surface of the mass. Said parallel nozzle may comprise its own conveyor belt for moving the mass.

After cutting the pressed mass into elements, the elements may be dried in an oven at elevated temperatures.

If necessary, the element may be pressed again, after drying, in a second pressing step. The second pressing step may be provided by the above second press or in a stationary press, e.g. of known type.

Preferably, the raw fibrous waste material and water (and polymer(s), cf. below) are pumped from their storage area and into said tank by pumping means.

A buffer tank containing said mixed mass may be provided in the installation, the mixed mass being transported from said buffer tank to the above-mentioned buffer container positioned above the conveyor belt supporting the mass.

The installation may further comprise a mill or blender for grinding and homogenising the mass before being pumped into said buffer tank.

By i.a. using the second press, the installation allows for a continuous manufacturing process of shaped elements, and therefore the mass may be transported continuously through said installation in one endless row until it is cut into said elements.

The installation according to the invention provides a shaped element having a much more uniform thickness and strength i.a. because the pressure is more evenly distributed on the mass, and because the drainage of the mass is much more consistent in the mass. In a stationary pressing step (prior art), the pressure may be unevenly distributed due to different drainage efficiency in the press - an uneven pressure provides non-uniform strength resulting in a breakage of the element.

When using a stationary press it is necessary to have enormous hydraulic cylinders providing a back pressure on outer surfaces of its side walls, as a high pressure is required to press the mass, as the major drainage takes place during this single pressing step. In the installation according to the invention, the mass is drained continuously on the conveyor belt during the two pressing steps, and there is thus no need of a high back pressure on the side surfaces of the first and second press(s) during pressing. Therefore, said hydraulic cylinders may be dispensed with and thus major installation costs is saved in relation to prior art installations.

The shaped element (preferably a sheet material) may be produced in a preferred quality without additives. However, considerable improvements may be made to the speed of production by adding chemical additives to the waste material, cf. the following paragraphs.

Cationic polymers of the type used in water purification and paper production may be added to the raw material during production, and which provides a considerable improvement in relation liberation of water from the raw material. Though, the mixing ratios are very critical in order to obtain the preferred effect, which may be a "short-lived" phenomenon.

The drainage period may e.g. be reduced with up to 30-55% in a raw material by using polymers.

The cationic polymers may be selected from (but limited to these) the group consisting of cationic polymers acrylic amide, cationic polyamines, dimethyldiallyl ammonium chloride polymers, cationic natural polymers, such as cationic starch, xanthan gum or carob tree gum.

Micro particles may be negative ion or cationic and may be natural such as bentonit or synthetic, which may be processed silicic acid or polyacrylamide micro particles in the form of negative ion or cationic.

Additions of e.g. resin polymers may also be used, such as acidiferous melamine formaldehyde or other systems based on condensation of polymers.

Further polymers of the polyhydroxide type may be added to improve the strength of the material. Such polymers are similar to polyvinyl alcohol, starch, etc.

Furthermore, the shaped element may be waterproof by adding resin-like additives of known type provided for saturating the shaped element, such as polyamide resin, or reactive silicone systems, wherein there is internal polymerisation of the reactive silicones in the moist sheet of material in order to provide a hydrophobic type.

Different kinds of additives may be added to the mixture, such as additives that makes the final shaped element water-repellent so that the element may be used in wet areas such as bathrooms.

The density of the final shaped elements manufactured in the installation according to the invention may be 1-2 tons pr. m^3. The modulus may be 2.500-5.000 N/mm^2, and the strength may be 2.5-10 N/mm^2.

According to a second aspect, the present invention relates to an apparatus for pressing a mass of fibrous waste material. The apparatus comprises

- an upper and a lower opposing surface, at least a part of one of the surfaces being perforated, so as to drain the mass when the mass is pressed between the surfaces, and

wherein at least one of the surfaces is adapted to vibrate in relation to the mass.

The lower surface may comprise a conveyor belt conveying the mass through said apparatus, and the upper surface may comprise vibrating pressing surfaces forming part of a vibration press and/or eccentric press, e.g. as the one described in connection with the first aspect.

Preferably, the upper and lower surface is perforated so as to obtain a good drainage of the mass.

The upper and lower surfaces may vibrate in relation to each other, so as to provide more vibration/shaking of the mass.

The upper and/or lower surface may be adapted to move the mass and may e.g. comprise conveyor belts.

Preferably, the apparatus further comprises opposing side surfaces in order to avoid mass leaving the conveyor belt(s) from the side during the belt pressing.

At least one of said pressing surfaces and/or side surfaces and/or the supporting surface may be perforated, so as to drain water from the mass when the mass is pressed between the surfaces.

The apparatus according to the second aspect may comprise any of the features of the first and second press of the installation according to the first aspect.

According to a third aspect, the invention relates to a method of manufacturing shaped elements from fibrous waste material. The method comprises the steps of:

- providing a raw material of fibrous waste material,
- mixing said raw material with at least water,
- transporting said mixed mass of waste material and water on a conveyor belt through a first press for pressing and draining said mass,
- transporting said mass through a second press for simultaneously pressing and vibrating the mass, and
- cutting said pressed mass into elements of predetermined lengths.

The transportation of said mass through the second press results in a more stable and hard form of the mass.

Preferably, the first and/or second press is adapted to co-operate with said conveyor belt, said press comprising;

- one or more pressing surfaces oppositely arranged in relation to a supporting surface of the conveyor belt supporting said mass, and
- opposing side surfaces,

at least one of said pressing surfaces and/or side surfaces and/or the supporting surface being perforated, so as to drain water from the mass when the mass is pressed between the surfaces, and

wherein at least one of said surfaces is vibrating in relation to the mass.

The method may further comprise, subsequently to the step of vibrating, the step of drying the mass at elevated temperatures. This step may be done in an oven at elevated temperatures.

The step of draining may comprise transporting the mass through a belt press, e.g. as the one described in connection with the first aspect, which may be perforated. Also the conveyor belt supporting the mass may be perforated for drainage of surplus water.

The method may further comprise, subsequently to the step of draining, the step of transporting said mass on the conveyor through a parallel nozzle. Said parallel nozzle is mainly provided for obtaining a smoother surface and a more uniform thickness of the mass before it enters the vibrating press.

In case a higher strength and thereby a higher density (than obtained by the pressing in the second press) of the element is required, the method may further comprise a third pressing step, said pressing step may be provided by said second press or a conventional stationary press, which may vibrate or be an eccentric press or be two oppositely arranged roller vibrating pressing surfaces. This further pressing step of the element may be provided after the element has been dried in the oven.

The mass may be pumped from the mixer to a buffer tank and/or buffer container before being provided on said conveyor belt, so that there always is material to position on the conveyor in order to obtain the continuous process of manufacturing.

The mass may be milled in a grinder or mill prior to entering the buffer tank in order to have a more uniform mass.

Preferably, the step of mixing comprising mixing the raw material so as to result in a water content in the mass of 75-90%, but the content of water may differ depending on which purpose the final shaped element is to be used for. The water content may be 50-90%, such as 55-85%, such as 60-80%, such as 65-75%, such as 70%.

Preferably, the step of mixing also comprises mixing the raw material with one or more chemical additives, such as polymers.

The raw material consists essentially of water, short cellulose fibres and fine mineral particles, and the step of draining in the belt press is carried out for a period of time sufficient to result in a water content in the pressed raw material of 20-50%, such as 25-45%, such as 30-40%, such as 35%, based on the dry weight of the cellulose fibres.

The water content of the mass after the second press may be 30-60%, such as 35-55%, such as 40-50%, such as 45%.

The drying step may comprise drying at a temperature in the range of 120-240°C, such as 150-220°C. The drying step may be carried out for a period of time sufficient to result in a water content in the material of not more than about 2-12%, such as preferably 5%.

However, the water content in the material after drying may be app. 0%, but it that case the final shaped element often needs to be coated on its surfaces in order to avoid that it absorbs moisture. If it absorbs moisture, the element will warp, in particular if more elements are placed closely next to each other.

The mass is transported continuously in an endless row on said conveyor belt, and the speed of the mass being transported through the presses may be 1-10 meter pr. minute, such as 2-9 or 3-8 or 4-7 or 5-6 meter pr. minute depending on the desired strength of the final element.

It is an advantage, that only the second press is vibrating and not the conveyor belt supporting the mass, as it is much easier to visually inspects the mass during pressing in order to control the process. Furthermore, it requires considerably less energy to vibrate only the press and not the entire conveyor belt with the mass thereon.

Also the first press may comprise vibrating elements for vibrating and pressing the mass in relation to the conveyor belt supporting the mass.

It should be understood that the method according to the third aspect might be carried out by the use of an installation according to the first aspect and e.g. by using an apparatus according to the second aspect.

The raw material of fibrous waste material mentioned in connection with the above aspects preferably comprises;

- 30-40% of water
- 60-70% of solids comprising:
    - 30-40% cellulose fibres
    - 65-70% chalk, clay and kaolin
    - 2-8% other ingredients, such as amines and scraps of soap.

The raw material preferably consists of pulp wasted from the reprocessing of paper. The pulp normally comprises 35-40% of water, but it is possible to start up with a pulp having a solid percent of 2-10%, which though requires more efficient and longer drainage.

The preferred water content in the mass may of course be obtained by adding water to the pulp, so that the mass e.g. may obtain a water percent of 75-90% before it enters the conveyor belt. Further, one or more polymers may be added to the mass, such as additives that provides a fire-retardant material and/or additives providing a water-repellent material, cf. above.

In order to increase the solid percent of the mass, filling material may be added. Preferably, the material that is cut away, when cutting the elements into preferred dimensions, is re-used as filling material. The filling material may also be dust from the manufacturing process.

The water content in the raw material of fibrous waste material may be 10-98%, such as 15-90%, such as 20-85%, such as 25-80%, such as 30-75%, such as 35-70%, such as 40-65%, such as 45-60%, such as 50-55%.

Any combination of the features of the aspects mentioned above is possible within the scope of the present application.

Now an embodiment of the method according to invention will be described.

<u>EXAMPLE</u>

In a preferred embodiment of the method according to the invention, the rest pulp consisting of app. 60% solids is placed in a mixer wherein water and a polymer, which may be diuretic, glue or another kind binding material, which may be combined to the raw material, and which may provide a satisfactorily stiffness and strength of the final shaped element.

The raw material is put into a rotating mixer, wherein the material is ground to a uniform mass, and subsequently it is pumped into a silo, the material now comprising 25-40% solids. The advantage of having a mass with low solid percent, is that it may be used for a continuous pressing process, where the mass is continuously conveyed through the press, in particular the vibrating and/or eccentric press according to the invention. The mass with the low solid percent provides a very fast water separation, as the water itself in this mass is diuretic - the more water in the mass the faster drainage, and a much better structure in the final element is obtained. This is in contrast to a stationary pressing, where it is necessary to have a high solid percent, as the mass need to be relatively stiff/stable prior to transporting it under or into a form of a stationary press.

The mass with the low solid percent is now transported on a conveyor belt through a filter belt press, wherein it is extruded in an oblong conical adjustable box/casing having side surfaces and a bottom and top surface, one or more of said surfaces being perforated, the surplus water in the mass is drained out through said perforations. At least the top surface may be adjustable so as to decrease or increase the intermediate distance between the top surface and the conveyor belt, and thereby provide a higher respectively lower pressure on the mass, so as to adjust the amount of drained water. The filter belt press may comprise vibration elements for vibrating the mass.

When a sufficiently amount of water has been drained/pressed out from the mass, the mass is conveyed further on through a parallel nozzle (which also may be provided with vibration elements) and into a vibration press, which, under the continuous conveying of the mass, vibrates and presses the mass to a relatively hard and stiff element. It is here possible to control the conveying speed of mass through the vibration press so as to control the desired strength of the final shaped element. Further, the vibration press may have an adjustable angling and slit opening so as to provide the desired pressure (kilo pr. cm^2) and thereby obtain the strength, thickness and shape of the final element that is desired.

Subsequently, the element is conveyed through an oven, wherein the element is dried to a preferred moisture content being desired in relation stock or sales conditions. Preferably, the temperature is between 120-240°C. If needed it may be transported through a further vibration and eccentric press in order to obtain an even higher density. Now, the element is ready for cutting and cleaning.

It is known to press in a stationary press, wherein the drainage time is much longer than the process according to the invention, the drainage time being almost 4-8 minutes longer

than the process according to the invention. Secondly, the elements cannot be conveyed in one endless line, as the process is dependent on the length of the stationary press, which may be 2-5 meters long. The vibration and eccentric press solve this problem.

By using the vibration and/or eccentric press, the pressure (kilo pr. cm^2) may be varied from inlet to outlet of the press. As the raw material normally is of a such bad quality, consisting of chalk, kaolin, clay, app. 30% short fibres from 0.5 - 0.8 millimetres, a special and steady method of drainage and finally a regularly vibration and/or eccentric press is required in order to obtain a satisfactorily quality of the final shaped element which is obtained by the method according to the invention.

In an embodiment of the invention, drum drainage may advantageously be used. The drum drainage may be used together with or without the filter belt drainage or in other cases extruding drainage and/or screw press drainage may be dispensed with. By using drum drainage, it is also possible to take material directly from the paper industry having a solid percent of app. 2-6%, as it is with the presses according to the invention.

Description of the figures

A detailed description of a preferred embodiment of the installation according to the invention will now be described with reference to accompanying figures, wherein figs. 1-3 show an installation for manufacturing shaped elements from fibrous waste material according to the invention.

Fig. 1 shows the first steps of manufacturing the shaped element. The raw material 1 is transported into a mixer 2 by use a screw conveyor 3, wherein the raw material is mixed with water 4 and various chemicals, such as polymers and glue 5. The chemicals are pumped 7 to the mixer 2 from a tank 6. The mixer 2 may comprise an agitator 8 for providing a uniform mass.

After being mixed the mass is pumped 7 into a mill or grinder 8, wherein the mass is crushed to provide an even more uniform mass. Subsequently, the mass is transported to a buffer tank 9, wherein it is stored until it enters the conveyor belt 10, cf. fig. 2

In fig. 2, the mass is continuously laid on the conveyor belt 10 in an endless row, as the belt is continuously moving forward. The belt 10 is driven by the rollers 11, said belt may be perforated so as to obtain a better drainage of surplus water. Firstly, the mass is conveyed through a filter belt press 12 (having a belt 12a driven by rollers 12b), wherein the mass is pressed and spread out horizontally in a continuous process, so as to drain

surplus water therefrom and press the mass. The distance between the belt press and the conveyor belt is decreasing in the forward direction so as to squeeze the mass, the thickness of the layer when leaving the belt press being between 5-20 mm, such as 10-15 mm.

The mass is now conveyed further on through a parallel nozzle 13, which ensures a smooth surface and a uniform thickness of the material before it enters the vibration press 14.

The vibration press 14 comprises vibrating and pressing elements 15 and a belt 16 moving with the same speed as the conveyor belt 10. The vibrating press presses the mass to a desired thickness and so that the element is provided with the desired strength, said strength and thickness being adjustable by changing the distance between the press 14 and the conveyor belt 10 and by changing the pressing time through changing the speed of the conveyor belt.

The vibration press, under the continuous conveying of the mass, vibrates the mass to a relatively hard and stiff element. The vibration and/or eccentric press may be adjusted up or down so that it provides the desired pressure (e.g. kilo pr. cm^2) and thereby obtains the strength of the final element that is desired.

The vibration press is vibrating independently in relation to the conveyor belt, but it could be that conveyor belt is vibrating too. As only the press is vibrating and not the conveyor belt, it is much easier to visually inspect the material during the pressing step, and much less energy is required to vibrate the press, instead the entire conveyor belt with the material on or even both.

Tests have shown that the vibration press provides a more uniform shaped element being lighter for a given strength than bodies pressed in a stationary press. One of the reasons is that the fibrous material is better shaken together, which provides a more opportune fibre structure and thereby better strength for a given weight.

When using a stationary press, the pressure must be kept at a sufficiently high level so that the mass is pressed to a thickness of e.g. 15 millimetres, and when the press is released from the mass, the mass will expand app. 3-5 millimetres. Thereby, the mass is stressed unnecessarily which unfortunately may result in a de-lamination of the element. By using said vibration press according to the invention this problem is solved.

After leaving the vibration press, the material may be cut (not shown) into elements/boards 17 of desired lengths depending on which purpose it should be used for.

The installation may comprise a cutting station for continuously cutting the endless row of material. The elements/boards may e.g. be used as wall element, shaped doors or other building elements.

Then the elements/boards are conveyed on a second conveyor 20 through a drier 18, wherein the elements are dried for a period of time sufficient to result in a water content in the material of not more than about 2-12%, such as 5% based on the dry weight of the element.

If necessary, the elements/boards 17 may pressed in a second press 19 after having been dried. This may be the case if the final shaped element requires an even higher strength and density than obtained through the vibration press.

Now the elements/boards are ready for sale or stock. The element may of course be surface treated afterwards, such as painted in a desired colour, or the element may be treated with a fire-retardant substance.

The above description should not be considered as a limitation of the invention, but only as an exemplification, and other variations and modifications thereof are possible within the limit of the following claims.